06-16-00

Docket No. 14XZ00087

UTILITY PATENT APPLICATION TRANSMITTAL

TO: Box PATENT APPLICATION
Assistant Commissioner for Patents
Washington, DC 20231

Transmitted herewith for filing under ☒ 35 USC 111(a) and ☒ 37 CFR 1.53(b) or ☐ 35 USC 371 is a new ☒ utility ☐ design patent application for an invention entitled:

METHOD OF VISUALIZATION OF A PART OF A THREE-DIMENSIONAL IMAGE

and invented by: Fabienne Betting, Jérôme Francois Knoplioch and Laurent Launay and Yves Trousset and Régis Vaillant

If a continuation application:

☐ continuation ☐ division ☐ continuation-in-part
of prior application Serial No.

Enclosed are:

1. ☒ Specification having twelve (12) comprising the following:
   - a. ☒ Claims numbered from 1 to 12
   - b. ☒ Abstract of the Disclosure
   - c. ☒ Drawing (s) as follows:
     - (1) ☒ Formal ☐ Informal
     - (2) Number of Sheets – two (2) with Figures No. 1-4
   - d. ☐ Oath or Declaration as follows:
     - (1) ☒ Original and signed
     - (2) ☐ Unsigned
     - (3) ☐ Copy from prior application Serial No. filed
     - (4) ☒ With Power of Attorney
     - (5) ☐ Without Power of Attorney
2. ☐ Incorporation by Reference (if Box 1d(3) is checked)
3. ☒ Assignment
   - ☒ Recordation Cover Sheet
   - ☒ Document

4. ☐ Preliminary Amendment

5. ☒ Acknowledgment Postcard

6. ☒ Certificate of Mailing by "Express Mail"

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 as Express Mail No. EJ127171942US on June 15, 2000 and is addressed to the Assistant Commissioner for Patents, Box PATENT APPLICATION, Washington, DC 20231.

Dolores K Tillson

(Name and Date) Dolores K. Tillson, June 15, 2000

7. ☒ Filing fee calculated and transmitted:

a. ☐ as described below for the claims as filed

			Small Entity		Large Entity	
For	No. Filed	No. Extra	Rate	Fee	Rate	Fee
Basic				$ 345		$ 690
Total Claims	12 - 20 =	-0-	X $ 9 =	$	x $ 18 =	$
Ind. Claims	1 - 3 =	-0-	X $ 39 =	$	x $ 78 =	$
Mult. Dep. ☐			+$130 =	$	+ $260 =	$
Total Filing Fee				**$ 345**		**$ 690**

b. ☐ see attached PTO-1398 for Transmittal Letter to US Designated/Elected Office for National Stage of PCT

c. ☐ design filing fee of $310.00

d. ☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. 09-0470 as described below. A duplicate copy of this sheet is enclosed.

(1) Charge the amount of ☐ $310.00 ☐ $345.00 ☒ $690.00 ☐ $ .00 for the filing fee.

(2) ☒ Credit any overpayment.

(3) ☒ Charge any additional filing fees required under 37 CFR 1.16 and 1.17.

(4) ☐ Charge the Issue Fee set in 37 CFR 1.18 at the mailing of the Notice of Allowance, pursuant to 37 CFR 1.311(b).

e. ☐ A check in the amount of $ for the filing fee is enclosed.

8. ☒ Information Disclosure Statement

a ☒ PTO-1449

b. ☒ Copies of Cited Documents

9. ☒ Certified Copy of Priority Document

Country France
Filing Date June 21, 1999
Application No. 99 07854
Applicant

10. ☐ Verified Statement to establish Small Entity status under 37 CFR 1.9 and 37 CFR 1.27

11. ☐ Additional Enclosures as follows:

a. ☐

b. ☐

Date: June 15, 2000

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METHOD OF VISUALIZATION OF A PART OF A THREE-DIMENSIONAL IMAGE

BACKGROUND OF THE INVENTION

The present invention concerns a method of visualization of a part of a three-dimensional image.

In the medical field, for example, three-dimensional images are frequently used to make diagnoses. In the field of radiology, notably, a three-dimensional image can embrace a multitude of interlaced blood vessels. During an examination, a radiologist may want to isolate a part of the image which seems of interest in order to visualize it in detail and establish a diagnosis. A side pocket formed by dilation of an arterial wall, an aneurysm in other words, may be hard to visualize in a three-dimensional image, especially when that pocket is hidden by a multitude of blood vessels. Even several rotations of the three-dimensional image in space do not always make it possible to visualize the aneurysm at a favorable angle. The same is true for the visualization of other pathologies such as stenosis.

There are known methods, described below, making it possible to isolate a part of a three-dimensional image.

It is known how to create zoom effects on an element of interest contained in a three-dimensional image, but the image thus obtained after zooming is not always of very good quality, owing to the fact that for small elements of interest it is necessary to make several enlargements (zoom).

Methods are also known for isolating a part of a three-dimensional image by cut planes. For this purpose, from a given three-dimensional image a cut plane is chosen by tracing a straight line on the three-dimensional image display window by means of a cursor. Thus, the part of the image present, for example, below the line traced is removed from the image. A new three-

dimensional image is obtained which is identical to an upper part of the original three-dimensional image.

Finally, the virtual scalpel method is known, making it possible to isolate a part of the three-dimensional image. The isolated part is determined with a free form. The radiologist determines any form by tracing a polygon on the three-dimensional image. The volume taken into account is a cylinder of section identical to the polygon and of infinite length in the direction perpendicular to the display window. A three-dimensional image is then obtained in which only the parts contained in the volume defined by the cylinder are visualized. However, this method has numerous disadvantages, namely:

- a lack of interactivity owing to the fact that the parts not visible are no longer accessible, the form obtained cannot be modified and another view necessitates tracing the polygon once again;

- failure to control the final volume, since the tracing is done is two dimensions and the lines of the tracing are interpreted in three dimensions according to particular rules;

- slowness due to "manual" tracing of the polygon.

BRIEF SUMMARY OF THE INVENTION

The present invention is intended to remedy the disadvantages of the aforesaid methods and to propose a method for rapidly isolating a part of a three-dimensional image and easily and interactively modifying the form of the volume visualized.

The invention therefore proposes a method of visualization of a part of a three-dimensional image. The three-dimensional image is shown on a display screen or on a window of the screen. The visualized part is defined by a finite predetermined volume, the center of which is located on an element of interest

present in the three-dimensional image. Being limited to a finite predetermined volume, any element present around the element of interest and outside the predetermined volume is no longer visible. The three-dimensional image obtained appears sharp, for only elements contained in the predetermined volume are visible. Most of the known methods applicable on any three-dimensional image, such as zoom, rotation of the three-dimensional image at different angles, etc., can advantageously be applied.

The three-dimensional image can be obtained following a magnetic resonance, a scanner or an X-ray exposure.

The final three-dimensional image is obtained in the predetermined volume by:

a) selecting a point on the element of interest,

b) creating in the three-dimensional image a volume whose dimensions are predetermined and whose center is the point on the element of interest,

c) making the intersection between the predetermined volume and the three-dimensional image,

d) displaying the part of the three-dimensional image contained in the predetermined volume.

In a preferred embodiment, the predetermined volume can be displaced in the three-dimensional image according to a translational motion, while displaying only the part of the three-dimensional image contained at each instant in the predetermined volume. In an embodiment of the invention it is interactive. By displacing (by translation) the predetermined volume in a two-dimensional space - that is, the center of the predetermined volume is displaced along a plane parallel to the display window, all of the elements of the three-dimensional image close enough to the plane to be visible in the predetermined volume can be scanned. The displacement is obtained by repeating stages b), c)

and d) and by taking as new center of the predetermined volume a point situated in the plane (plane parallel to the display window and passing through the first point taken as center of the predetermined volume) and away from the preceding center by a length chosen by the radiologist.

But preferably, rather than displacing the predetermined volume, the three-dimensional image is moved keeping the predetermined volume fixed on the display window.

According to another preferred embodiment, one displays the part of the three-dimensional image contained in the predetermined volume as well as any other part of the three-dimensional image not contained in a cylinder, with the predetermined volume, of section identical to the section of the predetermined volume and of infinite length, while any part of the three-dimensional image not contained in the cylinder is displayed in degraded mode.

The dimensions of the predetermined volume are advantageously changeable. The operator can choose to reduce or increase the predetermined volume. In order to do so, stages b), c) and d) are carried out, keeping the same center and changing the dimensions of the volume at the operator's choice.

The predetermined volume is preferably a sphere whose initial diameter is equal to half the width of the three-dimensional image display window. A shape other than the sphere can easily be chosen; a parallelepipedon or any other polyhedron whose equation of use is known can, for example, be taken.

According to one method of use of the invention, once the point is selected on the element of interest (stage a), a translation of the three-dimensional image is made, so as to place the point in the center of the three-dimensional display window.

Furthermore, the point can be selected by means of a cursor. The cursor can represent the movement of a mouse manipulated by the radiologist.

Other advantages and characteristics of the invention will appear on examination of the detailed description of a nonlimitative method of use and of the attached drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

- Figure 1 is a three-dimensional image containing a plurality of blood vessels and a hard-to-see aneurysm.

- Figure 2 is a three-dimensional image obtained according to the invention by isolating the aneurysm in particular.

- Figure 3 is a three-dimensional image obtained as a result of a translational motion with the image of Figure 2.

- Figure 4 is a view of the predetermined volume with a part of the three-dimensional image in degraded mode.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figure 1, a display window 1 shows a main blood vessel 2, branching out into a multitude of secondary blood vessels 2a-2f. On an upper part of the main blood vessel, there is an aneurysm 3 which is hard to distinguish, for it is surrounded by secondary blood vessels 2b-2f. When a radiologist wishes to study this aneurysm 3, he can pivot the image, in a manner well known to one skilled in the art, in order to visualize it at different angles. But, as can be seen on the image, the group of secondary blood vessels 2a-2f surrounding the aneurysm 3 prevents good visibility of the latter, whatever the angle of view. In order to be able to pass beyond the secondary vessels 2b-2f and enter a restricted space in which the aneurysm 3 is clearly visible, the invention provides for the isolating of the aneurysm 3 in a given volume.

The aneurysm 3 is selected by clicking above with a mouse manipulated by the radiologist. The mouse is sited on the display window 1 by means of a cursor 4.

Referring now to Figure 2, an algorithm finds the point selected by the cursor 4 in the three-dimensional space. This point is on the aneurysm 3. The three-dimensional image is moved by translation, so that the point selected by the cursor comes in the center of the display window 1. But it is entirely possible to move that point elsewhere on the display window 1. The center of the window has been chosen for reasons of convenience.

A predetermined volume is then established, which is shown as a sphere 5. The center of the sphere 5 is the point selected by the cursor 4 on the aneurysm 3. The center of the sphere 5 is visualized in the center of the display window 1. The radius of the sphere is chosen as equal to one-quarter the width of the display window 1. An intersection is then made between the sphere 5 and the three-dimensional image and only the parts of the blood vessels contained in the sphere 5 are displayed. The image obtained in the sphere 5 is also a three-dimensional image in which the aneurysm 3 is clearly visible, as is a neck 6 forming the junction between the blood vessel 2 and the aneurysm 3. It is then possible to perform zoom and three-dimensional rotation operations in order to visualize the neck 6 from other views. The radiologist can thus choose the intervention best suited to neutralize the aneurysm 3. The blood vessels 2c, 2e and 2f each contain a part in the sphere 5, while the parts outside the sphere 5 are cut.

It is also possible to vary the dimensions of the sphere by reducing (less elements visible) or enlarging (more elements visible) its radius. In order to do so, on each change of value of the radius of the sphere (entering the new value, for example, by means of a keyboard), from the same center, a new sphere of radius equal to the new value is determined, and then the intersection is made with the three-dimensional image.

It is possible that, starting from the image of Figure 2, if one clicks, with the mouse button pressed down, on a zone (see cursor 4) outside the sphere 5 and one drags the cursor 4 toward the top of the display window 1, a new image is obtained, according to Figure 3, in the sphere 5. A part of the main blood vessel 2 is visible here, while it was not in the image of Figure 2. The new image of Figure 3 is a new three-dimensional image in which another part of the three-dimensional image of Figure 1 can be seen, but shifted downward by a distance proportional to the movement of the cursor 4. For that purpose, on each movement of the cursor, upward, for example, a new point is determined on the initial three-dimensional image and then brought back to the center of the display window (the initial three-dimensional image is moved upward) and the intersection is made between the sphere and the three-dimensional image. The movement of the three-dimensional image is a translational motion along the plane of the display window.

As can be seen in Figure 4, another advantageous characteristic of the invention is the possibility of displaying the sphere 5 and a part of the three-dimensional image not contained in the sphere on the same window. The part not contained in the sphere is displayed in degraded mode, for example, with a weaker gray level than the gray level of the image contained in the sphere 5. To visualize the sphere 5 well, the part of the three-dimensional image not contained in the sphere is equivalent to a part of the three-dimensional image that would be determined by placing an empty cylinder, the axis of which is perpendicular to the display window 1 and passes through the center of the display window. Furthermore, the circular section of the cylinder has a diameter equal to the diameter of the sphere 5. Therefore, by visualizing the image of Figure 4, the initial three-dimensional image is visualized in degraded mode, except for the elements contained in the sphere 5, and any element situated in front of and behind the sphere 5 (in relation to the angle of vision of the display window) is erased.

The method disclosed makes it possible to isolate an element of interest in a three-dimensional image. This method enables an operator to save time by comparison with the previous methods. During a neuroradiology intervention, particularly for the embolization of aneurysms, it considerably increases the reliability of such therapeutic procedure.

Various modifications in structure and/or steps and/or function may be made by one skilled in the art without departing from the scope of the invention.

WHAT IS CLAIMED IS:

1. A method of visualization of a part of a three-dimensional image, wherein the part is defined by a finite predetermined volume, the center of which is located on an element of interest present in the three-dimensional image.

2. The method of visualization according to claim 1, wherein that the final three-dimensional image is obtained in the predetermined volume by:

a) selecting a point on the element of interest,

b) creating in the three-dimensional image a volume whose dimensions are predetermined and whose center is the point on the element of interest,

c) making the intersection between the predetermined volume and the three-dimensional image,

d) displaying the part of the three-dimensional image contained in the predetermined volume.

3. The method of visualization according to claim 1, wherein the predetermined volume can be displaced in the three-dimensional image according to a translational motion, while displaying only the part of the three-dimensional image contained at each instant in the predetermined volume.

4. The method of visualization according to claim 2, wherein the predetermined volume can be displaced in the three-dimensional image according to a translational motion, while displaying only the part of the three-dimensional image contained at each instant in the predetermined volume.

5. The method of visualization according to claim 1, wherein one displaying the part of the three-dimensional image contained in the

predetermined volume as well as any other part of the three-dimensional image not contained in a cylinder, with the predetermined volume, of section identical to the section of the predetermined volume and of infinite length, and in that any part of the three-dimensional image not contained in the cylinder is displayed in degraded mode.

6. The method of visualization according to claim 2, wherein one displaying the part of the three-dimensional image contained in the predetermined volume as well as any other part of the three-dimensional image not contained in a cylinder, with the predetermined volume, of section identical to the section of the predetermined volume and of infinite length, and in that any part of the three-dimensional image not contained in the cylinder is displayed in degraded mode.

7. The method of visualization according to claim 1, wherein once a part of the three-dimensional image is visualized in the predetermined volume, the dimensions of that predetermined volume can be modified by an operator.

8. The method of visualization according to claim 2, wherein once a part of the three-dimensional image is visualized in the predetermined volume, the dimensions of that predetermined volume can be modified by an operator.

9. The method of visualization according to claim 1, wherein the predetermined volume is a sphere whose diameter is equal to half the width of the three-dimensional image display window.

10. The method of visualization according to claim 2, wherein the predetermined volume is a sphere whose diameter is equal to half the width of the three-dimensional image display window.

11. The method of visualization according to claim 2, wherein once the point is selected on the element of interest, a translation of the three-dimensional image is made, so as to place the point in the center of the three-dimensional display window.

12. The method of visualization according to claim 2, wherein the point is selected by means of a cursor.

METHOD OF VISUALIZATION OF A PART OF A THREE-DIMENSIONAL IMAGE

ABSTRACT OF THE DISCLOSURE

The invention concerns a method of visualization of a part of a three-dimensional image. The part is defined by a finite predetermined volume, a sphere, for example, the center of which is located on an element of interest present in the three-dimensional image. In order to do so, a point is selected on the element of interest, a sphere is created in the three-dimensional image, the dimensions of which are predetermined and the center of which is the point on the element of interest, an intersection is made between the sphere and the three-dimensional image, and then the part of the three-dimensional image contained in the sphere is displayed.

FIG_1

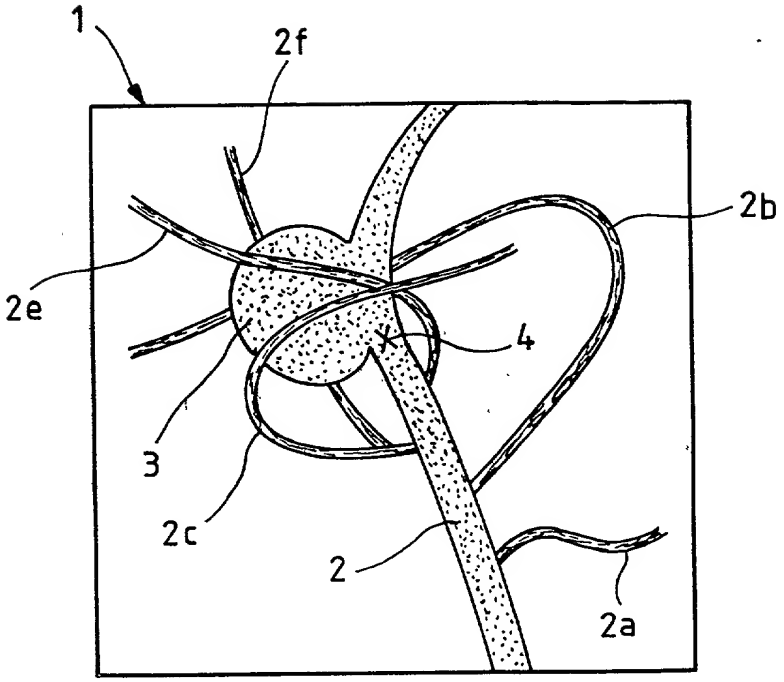


FIG_2

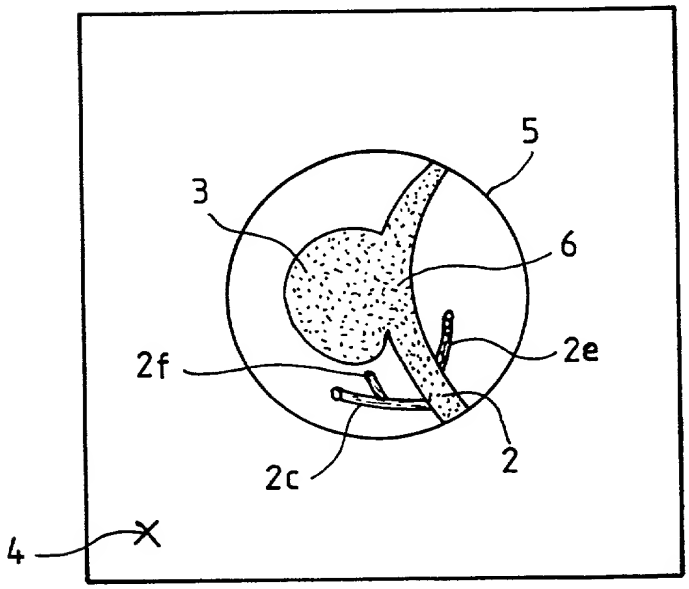


FIG_3

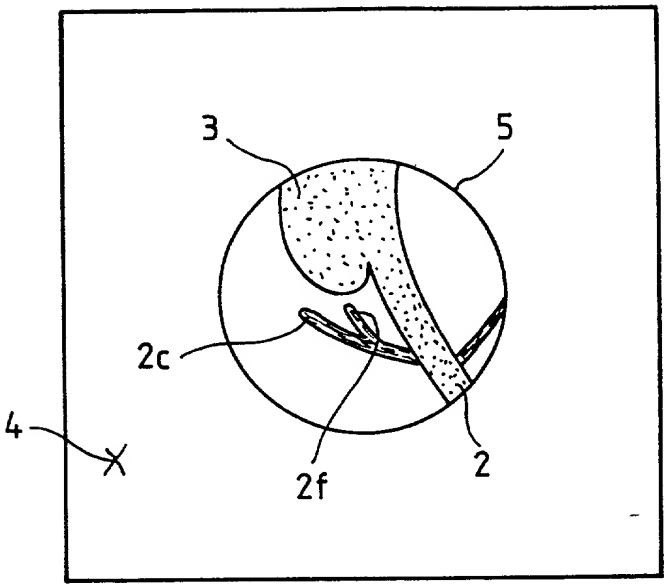
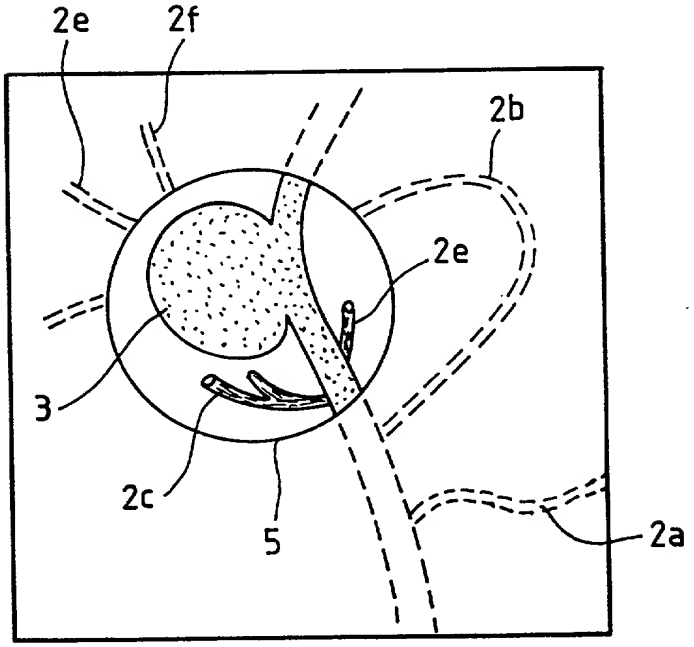


FIG_4



PATENT
Docket No. 14XZ00087

COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD OF VISUALIZATION OF A PART OF A THREE-DIMENSIONAL IMAGE

☒ the specification of which is attached hereto OR

☐ was filed on as Application Serial No. or PCT International Application Number and was amended on (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with 37 CFR §1.56.

I hereby claim foreign priority benefits under 35 U.S.C.§119(a)-(d) or 365(b) of any foreign application for patent or inventor's certificate listed below, and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 37 U.S.C. 119
France	99 07854	21 June 1999	☒ Yes ☐ No
			☐ Yes ☐ No

I hereby claim the benefit under 35 U.S.C. §120 of any United States application(s), or 365(c) of any PCT International application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of 35 U.S.C. §112, I acknowledge the duty to disclose material information as defined in 37 CFR §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. PARENT APPLICATION OR PCT PARENT NUMBER	PARENT FILING DATE (day, month, year)	STATUS (patent and number, pending, abandoned)

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s)listed below.

APPLICATION NUMBERS (S)	FILING DATE (day, month, year)

As a named inventor, I hereby appoint Christian G. Cabou (Reg. No. 35,467) and Phyllis Y. Price (Reg. No. 34,234) both of GE Medical Systems, 3000 North Grandview Blvd., Waukesha, Wisconsin 53188; Ronald E. Myrick (Reg. No. 26,315), Henry J. Policinski, (Reg. No. 26,621), and Jay L. Chaskin, (Reg. No. 24,030) all of General Electric Company, 3135 Easton Turnpike, Fairfield, Connecticut 06431-0001 jointly, and each of them severally, my attorneys, with full power of substitution, delegation and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent and Trademark Office connected therewith.

I hereby direct that all correspondence and telephone calls in connection with this application be addressed to Jay L. Chaskin, General Electric Company, 3135 Easton Turnpike, Fairfield, Connecticut 06431-0001, telephone number: 203-373-2867, fax number: 203-373-3991.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that all such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's signature: _____ Date: _____

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